Influence of Age and Postchill Carcass Aging Duration on Chicken Breast Fillet Quality

J. K. Northcutt,*[,1] R. J. Buhr,† L. L. Young,† C. E. Lyon,† and G. O. Ware‡

*Departments of Poultry Science and ‡Forest Resources, University of Georgia, Athens, Georgia 30602-4356; and †USDA, Agricultural Research Service, Richard B. Russell Agricultural Research Center, Athens, Georgia 30613-5677

ABSTRACT Breast fillet quality was evaluated from 37-, 39-, 42-, 44-, 46-, 49-, and 51-d-old broilers after postchill (PC) aging of the carcass 0, 2, 4, or 6 h and deboning. Fillets were vacuum sealed in cooking bags and heated to an internal temperature of 72 C by submersion in a 95 C water bath. Cook yield was determined as the weight percentage of the fillet remaining after cooking. Texture of the cooked fillets was measured using a Warner-Bratzler (W-B) shear device.

Fillet cook yield and shear force values were significantly affected by bird age at slaughter, and PC carcass aging duration before deboning. Bird gender significantly affected cook yield, whereas the interaction between age and PC aging duration significantly affected W-B shear. Fluid lost during cooking was greater for fillets aged 0 h PC and decreased when PC aging was 2 h or greater. Overall, W-B shear values decreased (more tender) when fillets were aged on the carcass at least 2 h PC, with the exception of fillets from 51-d-old broilers. After 2 h of PC aging on the carcass, shear force values for fillets from older broilers (49- and 51-d-old) were in the "very tough" portion of a texture scale (>12.60 kg), whereas textures of fillets from 42- and 44-d-old broilers were in the "slightly tough to slightly tender" portion of the scale (8.5 and 7.2 kg, respectively).

These data show that if poultry processors harvest fillets earlier than usual (<2 h PC aging), the fillet texture will be more tender if it originates from younger broilers (42- or 44-d-old) instead of older broilers (49- or 51-d-old).

(*Key words*: tenderness, shear, cook yield, breast fillet, carcass aging)

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INTRODUCTION

Over the last 40 yr, there has been a steady increase in the demand for convenient, portion-controlled, boneless cuts of poultry meat (USDA, 1995). Consequently, poultry processors are continuously searching for ways to improve processing efficiency to more easily meet these demands. One of the alternatives used to improve processing efficiency is removal of poultry meat from carcasses immediately after slaughter (Hamm, 1981, 1982; Lyon et al., 1985); however, numerous studies have shown that early harvesting of breast fillets results in tough, unacceptable texture (Pool et al., 1959; Lyon et al., 1973; Stewart et al., 1984; Lyon et al., 1985; Sams and Janky, 1986; Dawson et al., 1987; Smith and Fletcher, 1992). Texture of poultry breast fillets has been reported to improve as time between slaughter and deboning is increased. Dawson et al. (1987) found that chicken breast fillets aged less than 3.33 h postmortem had objectionably tough texture. Lyon et al. (1985) reported that as postchill (PC) carcass aging increased from 4 to 6 h before cut-up and deboning, the percentage of breast fillets (pectoralis major) rated as having acceptable tenderness increased from 60 to 95%. Acceptable tenderness was defined by these authors as a Warner-Bratzler (W-B) shear force less than 7.5 kg. However, it should be noted that the 7.5 kg value reported by Lyon et al. (1985) as the "demarcation line" between tough and tender meat was not substantiated by statistically analyzed sensory data and thus should not be overemphasized. In practice, poultry meat is generally aged on carcasses for at least 4 h PC before cut-up and deboning. Plant efficiency could be improved by shortening this aging duration, thereby reducing carcass storage space, storage costs, and the time to fill customer orders.

According to Martin (1995), changes in market trends have caused the broiler industry to evolve into specialty areas based on bird size and consumer preference. Depending upon the target market (i.e., fast food, retail, etc.), poultry meat may be deboned from broilers weighing as low as 1.75 kg to broilers weighing as much as 2.95 kg. However, much of the published research on carcass aging duration and texture has focused on broilers 6 to 7 wk of age and in the 1.8 to 2.2 kg weight range (Stewart et al., 1984; Lyon et al., 1985; Janky et al., 1992; Smith

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[1]To whom correspondence should be addressed: jnorthct@uga.edu.

and Fletcher, 1992; Dickens and Lyon, 1995). Cooper and Fletcher (1997) reported an exception in a study that compared texture of breast fillets from broilers in two live weight categories designated as "heavy" (3.0 kg) and "light" (1.8 kg). These authors reported that breast fillets from "heavy" broilers had shear force values that were significantly higher than breast fillets from "light" broilers after 4 and 24 h of PC carcass aging (6.5 versus 3.8 kg/g at 4 h PC and 4.4 versus 3.6 kg/g at 24 h PC). They postulated that fillet shear force values varied because of differences in the rates of rigor mortis development. The present study was conducted to determine variation in PC breast fillet texture (shear force) and cook yield from broilers at a variety of ages representing specialty and other markets for commercial processors (live weight 1.3 to 3.0 kg).

MATERIALS AND METHODS

Broilers

Mixed-sex, Ross broilers were hatched from commercially obtained eggs and grown to market age under simulated commercial conditions in floor pens within a single house. Chicks were fed medicated corn-soybean meal based starter (3,100 kcal ME/kg, 23% CP for 0 to 21 d), grower diets (3,200 kcal ME/kg, 19% CP from 21 to 35 d), and a nonmedicated finisher diet (3,200 kcal ME/kg, 19% CP from 35 to 50 d).

Processing

Four hundred forty-eight broilers were processed at 37, 39, 42, 44, 46, 49, and 51 d of age after a 10-h feed withdrawal period. On each day of processing, 16 birds (eight males and eight females identified by comb and wattle development) were removed from each of four duplicate pens (64 total birds), cooped, and transported less than 1 km to the pilot plant processing facility. Broilers were electrically stunned, head to shanks, in a brine stunner with fixed voltage of 50 V AC for 10 s, and a variable current of approximately 33 mA per broiler. Current was set to minimize the influence of any wing flapping on rigor onset in the fillets. Stunned broilers were transferred to restraining cones and bled for 90 s after severing both carotid arteries and at least one jugular vein. Broilers were then scalded for 120 s at 54.4 C in agitated water, mechanically defeathered for 30 s in a single unit commercial picker, and manually eviscerated. Gender was determined during evisceration by examination of gonads. Eviscerated carcasses were tumble-chilled in ice water for 30 min and were allowed to drain for 5 min.

Carcass Aging and Fillet Cooking

Carcasses representing broilers from one pen (batch) were randomly divided into groups of four carcasses each and were aged PC for 0, 2, 4, or 6 h on ice in a 4 C cooler before manually deboning left and right pectoralis majors (fillets). Zero-hour carcasses were allowed to drain for 5 min before deboning. Fillets were stored overnight at 4 C in tied plastic bags. After the 24-h storage, fillets were tempered to 20 C for 1 h and weighed, and a cooking thermometer was inserted into the center of each muscle. Fillets were vacuum sealed in labeled cooking bags and heated in a 95 C water bath to an internal temperature of 72 C. When the fillets reached the desired internal temperature, they were removed from the water bath, submerged in ice water for 15 min, and stored overnight at 4 C.

Abbreviation Key: PC = postchill; W-B = Warner-Bratzler.

TABLE 1. Statistical significance of main effects and interactions on cook yield and W-B[1] shear force of chicken breast meat

Source	Cook yield	W-B shear
Age	0.0001	0.0005
Aging duration	0.0005	0.0001
Gender	0.031	0.622
Age by aging duration	0.139	0.0022
Age by gender	0.918	0.045
Aging duration by gender	0.331	0.723
Age by aging duration by gender	0.858	0.084

[1]W-B = Warner-Bratzler.

Cook Yield and Fillet Texture Analyses

On the following day, fillets were removed from the bags, tempered to 20 C for 1 h, blotted dry, and reweighed. Cook yield was reported as the weight percentage of the fillet remaining after cooking.

Texture of the cooked fillets was measured as described in a previous study (Young et al., 1991). Briefly, two 1.9 cm wide strips were cut parallel to a line beginning at the humoral insertion and ending at a point adjacent to the keel, and included the complete depth of each muscle. Force (in kg) required to shear strips across the longitudinal axes of the fibers was measured using a Warner-Bratzler (W-B) shear device. Shear force was determined on adjacent duplicate samples for the left and right fillets.

Statistical Analysis

The experiment was conducted as a split-plot design. The whole-plot effect of bird age (age) was tested using the error term batch (pen) within age. The subplot effects consisted of aging duration, gender, aging duration by gender, and the appropriate interaction effects with age. Means were separated with the least-squared means option of the general linear model procedure of the SAS/STAT program by using a significance level of $P < 0.05$ (SAS Institute, 1994).

RESULTS AND DISCUSSION

Analyses of variance for cook yield and W-B shear is shown in Table 1. Bird age at slaughter and PC carcass

TABLE 2. Effect of age at slaughter on cook yield of chicken breast meat

Age (d)	Cook yield (%)
37	75.6[d]
39	80.5[a]
42	78.4[c]
44	79.4[b]
46	77.2[c]
49	79.3[b]
51	80.6[a]
SEM	0.14

[a–d]Means with no common superscripts differ significantly ($P < 0.05$).

aging duration had a significant affect on both cook yield and W-B shear values. Gender, which is related to bird size and thus raw fillet weight, had a significant affect on cook yield but no effect on W-B shear values. Additionally, the interaction between bird age at slaughter and PC carcass aging affected W-B shear values but had no effect on cook yield.

Table 2 shows the effect of bird age at slaughter on cook yield of broiler breast fillets. Cook yield values ranged from approximately 76 to 81% with the lower yield values originating from 37-d-old broilers, and the higher yield values originated from 39- and 51-d-old broilers. Comparable breast fillet cook yield values were obtained from broilers 42 and 46 d of age or from broilers 44 and 49 d of age (approximately 78 and 79%, respectively). These values are similar to those previously reported by Poole et al. (1999) in their study of the relationship between broiler age, gender, strain, and diet on breast fillet cook yield and shear.

Fillets removed from the carcass immediately after slaughter (0 h PC) had the lowest cook yield; however, fluid lost during cooking decreased (higher yield) when fillets were aged 2, 4, or 6 h, with no significant difference between these cook yield values (Table 3). Dickens and Lyon (1995) reported that cook loss from broiler breast meat decreased from 20.2 to 18.1% as postmortem deboning time increased from 1 to 3 h. Dawson et al. (1987) found that cooked meat moisture of broiler fillets increased as postmortem deboning time increased, and maximum meat moisture was attained after 3.33 h of carcass aging. Although this 3-to-4-h delay in postmortem fillet deboning time corresponds to the time required to complete rigor mortis development in broiler carcasses, researchers have suggested that rigor development has no affect on cook yield because the process of heating denatures proteins and disrupts membranes separating intracellular and extracellular water (Hamm, 1986; Honikel, 1987; Honikel and Hamm, 1995). Fillets deboned immediately postmortem, however, do not have significant drip loss, whereas drip loss occurs in fillets deboned after rigor mortis (Hamm, 1986; Offer and Knight, 1988; Honikel and Hamm, 1995). In the present study, fillets from broilers within an age group that were harvested early (0 h PC) weighed slightly more (initial raw weight) than fillets harvested after rigor mortis (4 and 6 h PC; Young et al., 2001). A portion of this extra weight could be fluid retained in the fillet during rigor mortis, but lost during cooking and contributing to higher cook loss for early-harvested fillets as compared to aged fillets.

TABLE 3. Effect of aging duration on yield of cooked chicken breast meat

Aging duration (h)	Cook yield (%)
0	77.8[b]
2	78.7[a]
4	79.2[a]
6	79.2[a]
SEM	0.14

[a,b]Means with no common superscripts differ significantly ($P < 0.05$).

Table 4 shows breast fillet W-B shear force values after cooking for each combination of bird age and PC carcass aging duration. Irrespective of bird age at slaughter, fillets deboned immediately PC (0 h aging) had the highest shear values (>14.6 kg force). When fillets were aged on the carcass at least 2 h PC, force-to-shear values decreased, with the exception of shear for fillets from 51-d-old broilers, which remained comparable to its 0 h PC shear value. These findings agree with those previously reported for broiler breast fillet shear in which shear was found to decrease with increasing PC carcass age (Stewart et al., 1984; Lyon et al., 1985; Dawson et al., 1987; Smith and Fletcher, 1992).

As noted earlier, Lyon et al. (1985) reported that a W-B shear value of 7.5 kg could be used as a demarcation line between tough and tender, but no statistically analyzed sensory data were presented to verify this shear value. Lyon and Lyon (1991) conducted a study to establish the relationship between objective shear tests, including W-B and a sensory panel's perception of texture (very tough to very tender) for broiler breast meat. According to the criteria established by Lyon and Lyon (1991), fillets had corresponding sensory and shear values of "very tough" (<12.60 kg force), "moderate to slightly tough" (12.60 to 9.61 kg force), "slightly tough to slightly tender" (9.60 to 6.62 kg force), and "slightly tender to moderately tender" (6.61 to 3.62 kg force). With the texture scale established by Lyon and Lyon (1991), the shear values for the present study indicate a range from "very tough" (>12.60 kg) to "moderately tender" (3.62 kg) for breast fillets. Regardless of bird age, all fillets deboned at 0 h PC would be considered "very tough" based on shear values greater than 12.60 kg. The study by Lyon et al. (1985), comparing various PC deboning times, was conducted under commercial conditions, and the mean W-B shear values for the 0 h PC breast fillets was 15.19 kg. That value is similar to the 0 h PC shear values found in the present study (16.3 kg). After 2 h of PC aging on the carcass, shear force values for breast fillets from older broilers (49 and 51 d) were still in the "very tough" portion of the texture scale, whereas shear force values for fillets from 37, 39, and 46-d-old broilers were in the "moderate to slightly tough" (12.60 to 9.61 kg force) texture range (Lyon and Lyon, 1991). Shear values of fillets from 42- and 44-d-old broilers aged 2 h PC were in the "slightly tough to slightly tender"

TABLE 4. Effects of bird age at slaughter and carcass aging duration on Warner-Bratzler shear values of cooked chicken breast meat

	Shear values (kg)			
Age (d)	0 h	2 h	4 h	6 h
37	15.3[a,y]	11.9[b,y]	4.0[c,x]	5.9[c,x]
39	14.8[a,y]	10.1[b,y]	4.0[c,x]	3.7[c,x]
42	15.1[a,y]	8.2[b,z]	4.3[c,x]	5.7[c,x]
44	16.4[a,y]	7.3[b,z]	3.7[c,x]	4.4[c,x]
46	17.5[a,x]	11.0[b,y]	6.0[c,x]	4.3[c,x]
49	19.8[a,x]	15.1[b,x]	4.9[c,x]	4.4[c,x]
51	14.6[a,z]	14.5[a,x]	4.8[b,x]	4.6[b,x]
SEM	0.40	0.56	0.22	0.44

[a–c]Means in the same row with no common superscripts differ significantly ($P < 0.05$).

[x–z]Means in the same column with no common superscripts differ significantly ($P < 0.05$).

(9.60 to 6.62 kg force) portion of the scale. After 4 and 6 h of PC carcass aging, shear values of fillets for broilers from every age group were in the "slightly tender to moderately tender" (6.61 to 3.62 kg force) portion of the texture scale.

Table 5 shows the effects of bird age at slaughter and gender on breast fillet W-B shear values. The W-B shear for fillets from male and female broilers was found to be comparable at every bird age, with the exception of fillets from 46-d-old broilers. At 46 d of age, W-B shear for fillets from female broilers was significantly lower, and would be considered to be "slightly tender" (6.62 kg) to "slightly tough" (9.60 kg), than the shear for fillets from male broilers, which would be considered to be "moderate to slightly tough" (12.60 to 9.61 kg). Among the female broilers, there was no clearly defined age-related trend for W-B shear. Shear values for fillets from 37- 49-, and 51-d-old broilers were found to be similar, whereas shear values for fillets from 39-, 42-, 44-, and 46-d-old broilers were found to be similar. The W-B shear values for fillets from male broilers increased when broilers reached 46 d of age. Shear values were highest for fillets from male broilers 46, 49, and 51 d of age and lowest from fillets from male broilers 37, 39, 42, and 44 d of age.

These data demonstrate that bird age at slaughter and PC carcass aging duration before deboning are critical to breast fillet cook yield and texture. However, carcass aging beyond 4 h PC resulted in little improvement in fillet texture, noted as force to shear. Data also indicate that poultry processors harvesting breast fillets earlier than 2 h PC should process 42- or 44 d-old broilers instead of 49- or 51-d-old broilers, because the texture of the younger birds is more desirable. This information could be of particular interest to plants categorized as "big bird deboners" (2.5 to 2.95 kg birds), where more than 98% of their market is cut-up and deboned poultry (Martin, 1995).

TABLE 5. Effects of bird age at slaughter and gender on Warner-Bratzler shear values of cooked chicken breast meat

	Shear values (kg)	
Age (d)	Females	Males
37	9.9[a,x,y]	8.7[a,y,z]
39	8.5[a,y]	7.9[a,z]
42	8.0[a,y]	8.7[a,y,z]
44	8.4[a,y]	7.5[a,z]
46	8.3[b,y]	11.1[a,x]
49	11.8[a,x]	10.3[a,x]
51	9.9[a,x,y]	9.4[a,x,y]
SEM	0.49	0.38

[a–c]Means in the same row with no common superscripts differ significantly ($P < 0.05$).

[x–z]Means in the same column with no common superscripts differ significantly ($P < 0.05$).

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